

BELLCOMM. INC.

1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: Apollo Circuit Breakers as Ignition
Sources - Case 320**DATE:** September 11, 1968**FROM:** W. H. HodgeMEMORANDUM FOR FILE

Attached are copies of vu-graphs (Attachment 1) used in a presentation to the Apollo Program Office during the regular morning meeting on 3 September. The purpose of the presentation was to outline considerations leading to the conclusion that the Apollo circuit breakers are not likely ignition sources.

It was pointed out that the extensive testing history of the breakers without indications of trouble in this area support our conclusion. The Apollo breakers are essentially environmentally-sealed versions of breakers designed by the vendor, Mechanical Products, Inc., to Military Specification C-5809. To support that design, the breakers had been subjected by Mechanical Products to severe overloads (e.g., 6000 amps interrupted by 5 amp breakers) and to explosion-proof testing in mixtures of air and aviation gasoline. That testing, plus testing to the Apollo procurement spec (common-use by GAEC and NR) and subsequent testing by MSC at 600% overload (i.e., rupture current) in 14.7 psia pure oxygen, leads to the conclusion that the breakers used in both the Command Module and the Lunar Module can safely contain a rapid energy release and can safely interrupt severe overloads. The Apollo Spacecraft Program Office at MSC, with whom we have worked on this problem, has reached the same conclusion. Their position has recently been outlined in a letter (Attachment 2) from the Spacecraft Program Manager to the Apollo Program Manager.

W. H. Hodge
W. H. Hodge

2031-WHH-tfb

Attachments (2)

NASA FILE 607**(NASA-CR-104018) APOLLO CIRCUIT BREAKERS AS
IGNITION SOURCES (Bellcomm, Inc.) 16 p****N79-72791****Unclas
11483**

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(CATEGORY)**(NASA CR OR TMX OR AD NUMBER)**

APOLLO CIRCUIT BREAKERS - IGNITION SOURCES?

- NORMALLY SEPARATE FUEL FROM POSSIBLE IGNITION SOURCES
 - CIRCUIT BREAKERS ARE FUEL
 - ARE CIRCUIT BREAKERS IGNITION SOURCES?
 - RUPTURE - FAIL SAFE?
- CONSIDERATION OF THE PROBLEM
- MSC RESPONSE
- CONCLUSION - APOLLO CIRCUIT BREAKERS ARE NOT LIKELY IGNITION SOURCES
- REVIEW CONSIDERATIONS LEADING TO CONCLUSION

AEROSPACE CIRCUIT BREAKERS

- TYPES

- MAGNETIC

- THERMAL

- APOLLO BREAKERS MADE BY MECHANICAL PRODUCTS INC.

- APOLLO BREAKERS ARE THERMAL

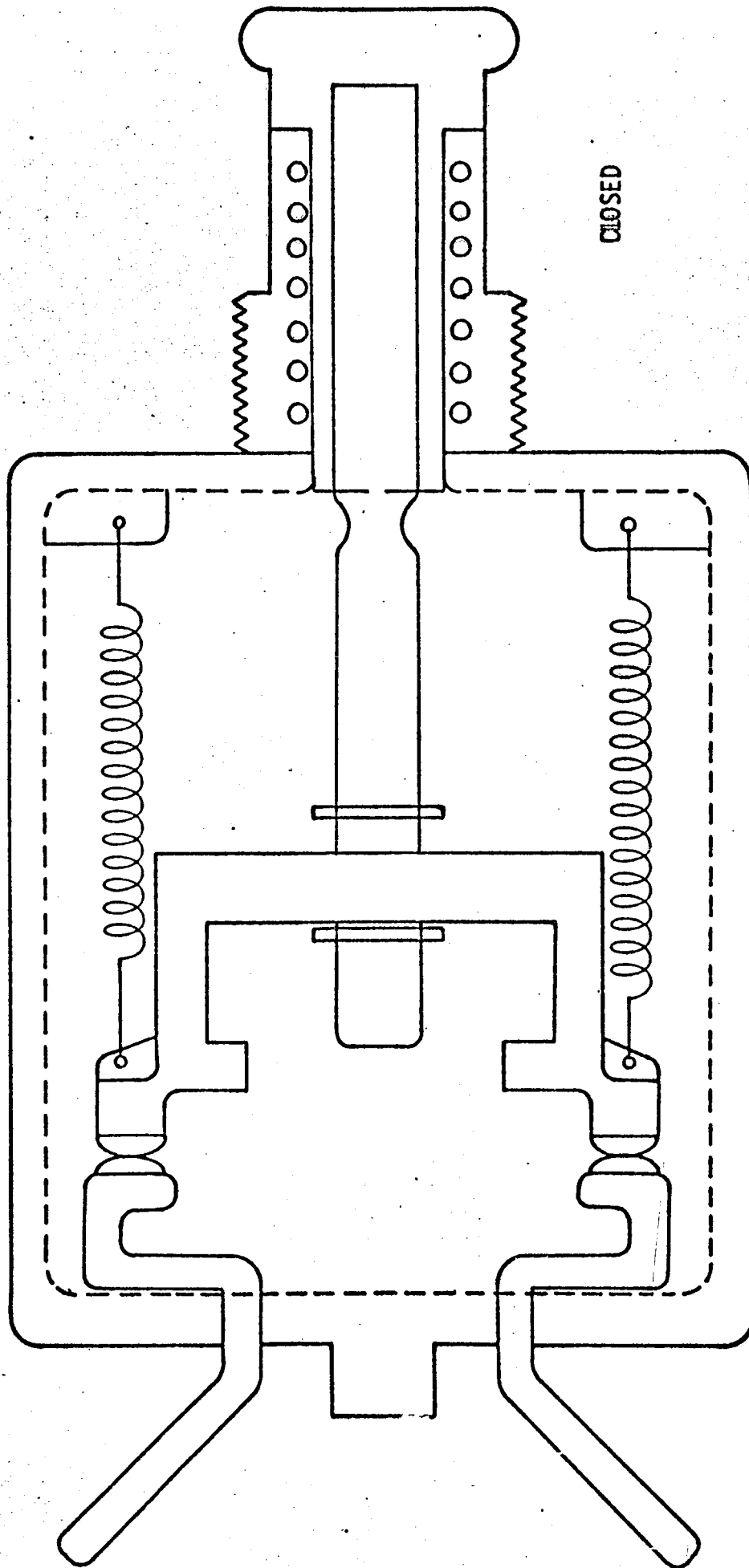
- BIMETALLIC STRIP

- HOT-WIRE

APOLLO BIMETALLIC STRIP CIRCUIT BREAKERS

- USED IN DC CIRCUITS
 - HIGH CURRENT - LOW RESISTANCE
- COMMAND MODULE
 - MORE THAN 150
 - 5 AMPS TO 100 AMPS
- LUNAR MODULE
 - APPROXIMATELY 100
 - 3 AMPS TO 70 AMPS
- MATERIALS
 - MELAMINE CASE
 - NO INTERNAL WIRE INSULATION
 - MISCELLANEOUS
- 2 SETS OF SERIES CONTACTS

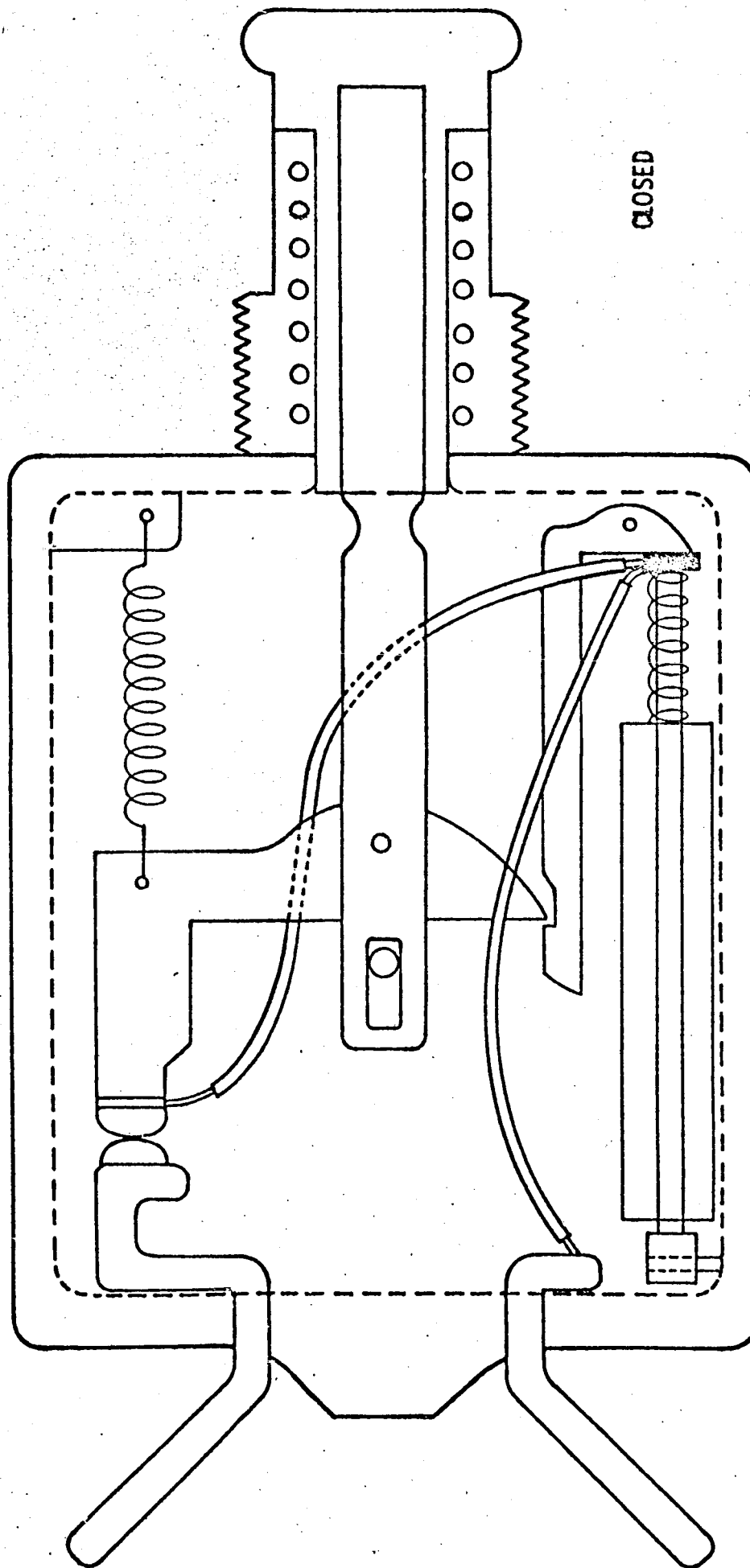
APOLLO CM & LM
BIMETALLIC STRIP CIRCUIT BREAKER
(Simplified Drawing)



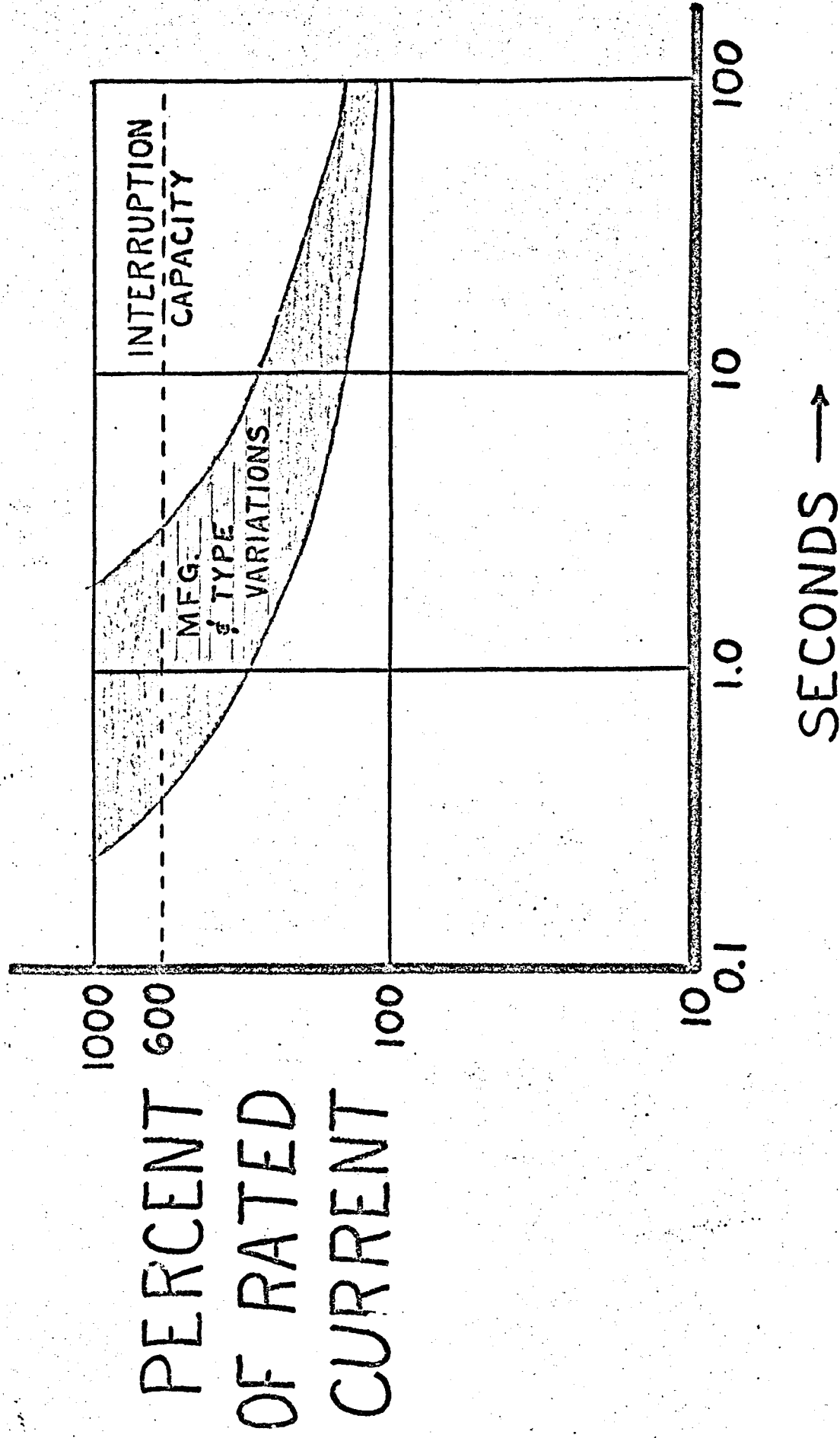
APOLLO HOT WIRE CIRCUIT BREAKERS

- USED IN AC CIRCUITS
- LOW CURRENT - MORE SENSITIVE
- COMMAND MODULE
- APPROXIMATELY 50
- 2 AMPS TO 3 AMPS
- LUNAR MODULE
- APPROXIMATELY 50
- 1 AMP TO 5 AMPS
- MATERIALS
- DIALLYL CASE - GOOD THERMAL INSULATOR
- SILICONE RUBBER INSULATED INTERNAL WIRING
- MISCELLANEOUS
- SINGLE SET OF CONTACTS

APOLLO CM & LM
HOT WIRE CIRCUIT BREAKER
(Simplified Drawing)



9. TYPICAL APOLLO C/B TRIP CURVE



TRIPPING TIME

SPECIFICATION PROVISIONS

• MATERIALS

" PLASTIC MATERIALS USED SHALL NEITHER
SUPPORT COMBUSTION NOR GIVE OFF
NOXIOUS GASES WHEN SUBJECTED TO ARCS,
SUCH AS THOSE CAUSED BY INTENTS, OR
HEAVY SHORT CIRCUIT CURRENTS, OR
EXPLOSIONS OF GASEOUS VAPORS, TO WHICH
THE MATERIALS MAY BE SUBJECTED IN
SERVICE." (Para. 3.4.2 of MIL-C-5809D)

SPECIFICATION PROVISIONS

• RUPTURE

- "A CURRENT OF 600% RATED LOAD APPLIED TO THE BREAKER IN A 100% OXYGEN ATMOSPHERE AT 5 PSIA SHALL NOT CAUSE EXPLOSION, FIRE, OR STRUCTURAL DAMAGE TO THE BREAKER CASE, CONNECTORS, MOUNTINGS, OR SURROUNDING EQUIPMENT." (Para. 4.4.17 of MC 454-0010)

SPECIFICATION PROVISIONS

- EXPLOSION TEST

- REPEATED OPERATION
- AIR/AVIATION GASOLINE
- 14.7 PSIA

"IGNITION OF THE EXPLOSIVE MIXTURE OUTSIDE
THE BREAKER SHALL CONSTITUTE FAILURE."
(Para 4.6.20 of MIL-C-5809D)

- TESTS BREAKER ABILITY TO CONTAIN RAPID
ENERGY RELEASE

EXTRA TESTING

•MECHANICAL PRODUCTS

- MIL SPEC TESTING OF MS BREAKERS
- NORTH AMERICAN ROCKWELL
- CLOSED CONTACTS
- 16 PSIA PURE OXYGEN

•MSC

- SIX 10 AMP BREAKERS
- 14.7 PSIA PURE OXYGEN
- 600% RATED CURRENT
- NO DAMAGE TO BREAKERS

MSC RESPONSE

- CONSIDERABLE TESTING WITH NO IGNITION PROBLEMS

- MIL SPEC BREAKER

- APOLLO BREAKER

- QUAL TESTS

- CIRCUIT BREAKER/WIRE COMPATIBILITY

- RECENT MSC TESTS

- MSC CONCLUSION - NOT A PROBLEM

CONCLUSION

- LARGE AMOUNT OF TESTING UNDER VARIETY OF EXTREME CONDITIONS WITH NO HISTORY OF IGNITION DIFFICULTIES
- APOLLO CIRCUIT BREAKERS ARE NOT LIKELY IGNITION SOURCES



Attachment 2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

IN REPLY REFER TO: PD4/1853-68-PA

AUG 12 1968

TO : NASA Headquarters
Attention: Lt. General Samuel C. Phillips, MA

FROM : Manager, Apollo Spacecraft Program

SUBJECT: Testing to exempt circuit breakers as ignition sources

This letter is in response to your question concerning whether the circuit breakers used on the Apollo spacecraft represent ignition sources.

There is a considerable amount of data related to this subject as generated by Mechanical Products Incorporated, the manufacturers, in meeting military specification requirements and the North American Rockwell Corporation procurement specification requirements. Two types of circuit breakers were tested in generating these data: (1) a nonenvironmentally sealed breaker, the commercial or military version, and (2) an environmentally sealed circuit breaker, the Apollo spacecraft version. The implementation of the environmental seal results in the sealing of all areas of the circuit breaker, except for a portion of the operating shaft and the terminals. The shaft seal is metal-to-metal using two piston ring type seals. Since the military, or unsealed, version has undergone considerable testing with no problems, we consider these data applicable to the Apollo spacecraft circuit breaker.

The military version of this circuit breaker has been repeatedly explosion-proof tested in accordance with military specification MIL-C-5809C and D as specified by MIL-E-5272C, Procedure I, or MIL-STD-810. The circuit breaker has passed this testing on all occasions. As recently as the fall of 1967, this circuit breaker was tested in accordance with MIL-C-5809D. During this testing, 51 circuit breakers were subjected to the rupture test and 8 circuit breakers were subjected to the explosion-proof test. All of the circuit breakers passed these tests. The data from this latter test have been transmitted to Mr. William H. Hodge, MAS, under separate cover.

The Apollo spacecraft version of this circuit breaker has also had a considerable amount of testing performed on it.

In the basic qualification testing, the Apollo Spacecraft Program Office did accept testing accomplished on the military version in satisfying the explosion-proof requirement. The Apollo spacecraft version was subjected to rupture testing. The test was accomplished in a 100% oxygen, 5 psia atmosphere. A number of circuit breakers were subjected to currents that were 600% of circuit breaker rating. After the test, the circuit breakers were examined for evidence of rupture, explosion, fire, or sustained arcing. All of the circuit breakers passed this test.

While accomplishing the Block II wire/circuit breaker compatibility study, 45 circuit breakers were forced to operate 275 times in a 100% oxygen, 5 psia atmosphere at various loads. None of these breakers exhibited any evidence of rupture, explosion, fire, or sustained arcing. After the testing, the circuit breakers were checked for calibration and found to be acceptable. Again, these data have been transmitted to Mr. William H. Hodge, MAS, under separate cover.

The above described tests were all conducted either in air, rupture testing on the military version; a fuel rich environment, explosion-proof testing on the military and Apollo testing; or a reduced pressure oxygen rich environment, rupture, and compatibility testing on the Apollo version.

MSC conducted tests in June 1968, to acquire data in a high pressure 100% oxygen environment. Two test panels with three 10 ampere circuit breakers mounted on each were placed in an altitude chamber. The chamber was evacuated to less than 0.5 mmHg and this pressure was maintained for six hours minimum. The chamber was back-filled with 95% oxygen to a pressure of 14.7 psia and the circuit breakers were allowed to soak at this pressure for six hours minimum. The circuit breakers were subjected to 115% of rated current for 45 minutes and then the current was increased to 600%. All circuit breakers tripped nominally with no explosion, rupture, or fire. The circuit breakers were then subjected to normal electrical acceptance tests and all passed.

The Apollo Spacecraft Program Office feels that the accumulated testing is sufficient to eliminate the circuit breaker as a potential ignition source.

George M. Low
George M. Low B-12

*Sam - this does not prove that a defective circuit
cc: NASA Hqs., William H. Hodge, MAS breaker might not be
an ignition source. However, presumably our
functional testing would screen out defective
breakers - MHL*

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FROM: W. H. Hodge

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